



Massachusetts Water Resources Authority

**After the Boston Harbor Project:
How Clean is the Harbor?
How Clean is the Bay?**

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MWRA**

NESSA May 8, 2003





Three Stages of Boston Harbor Cleanup



- 1985-July 1988
- Better disinfection
- Sludge discharges end

- July 1988-September 2000
- Secondary Treatment begins
- NITP closed, ending discharges to southern harbor

- September 2000-present
- Discharge to Mass Bay; end of treatment plant discharges to harbor

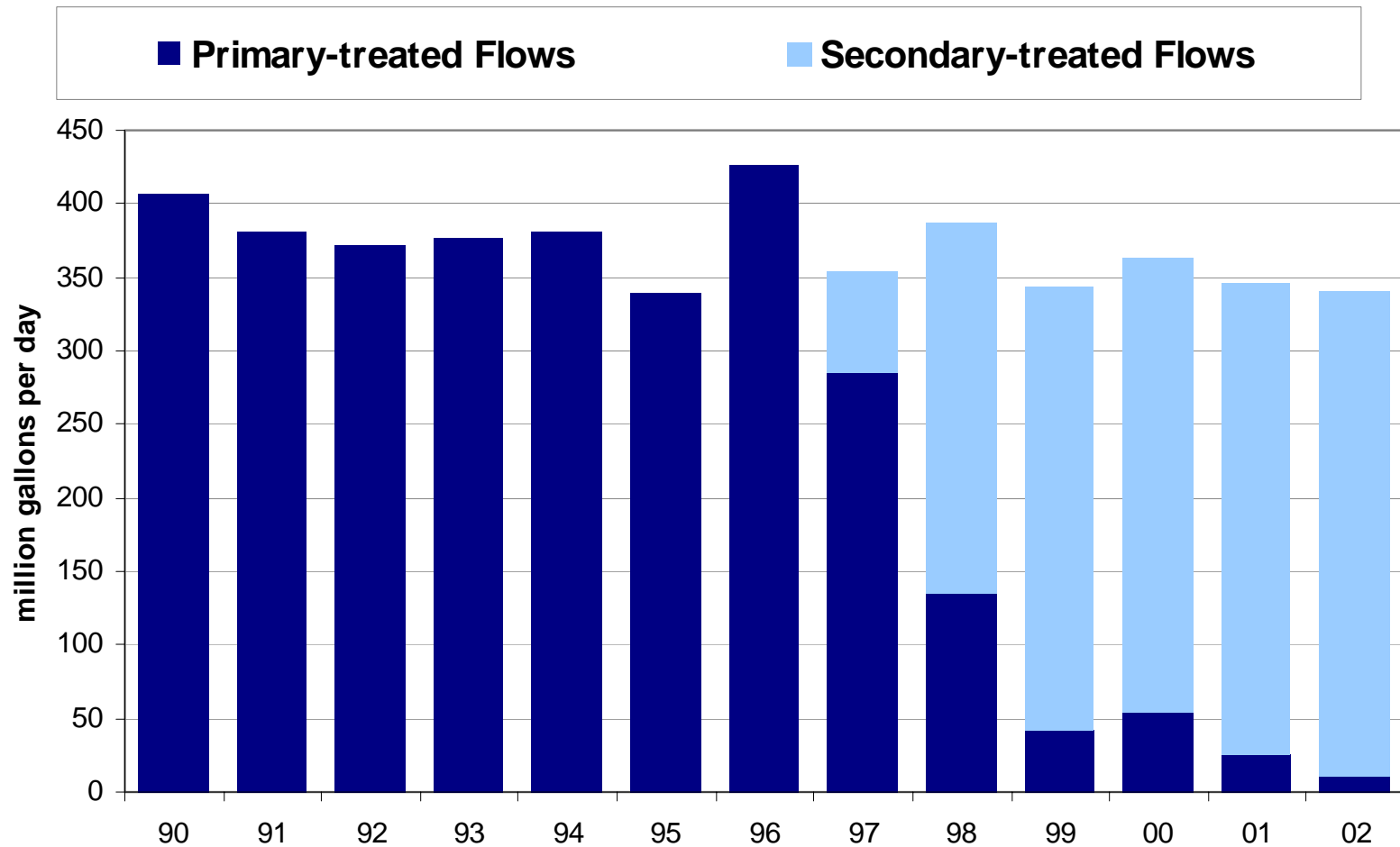


EFFLUENT QUALITY MONITORING RESULTS



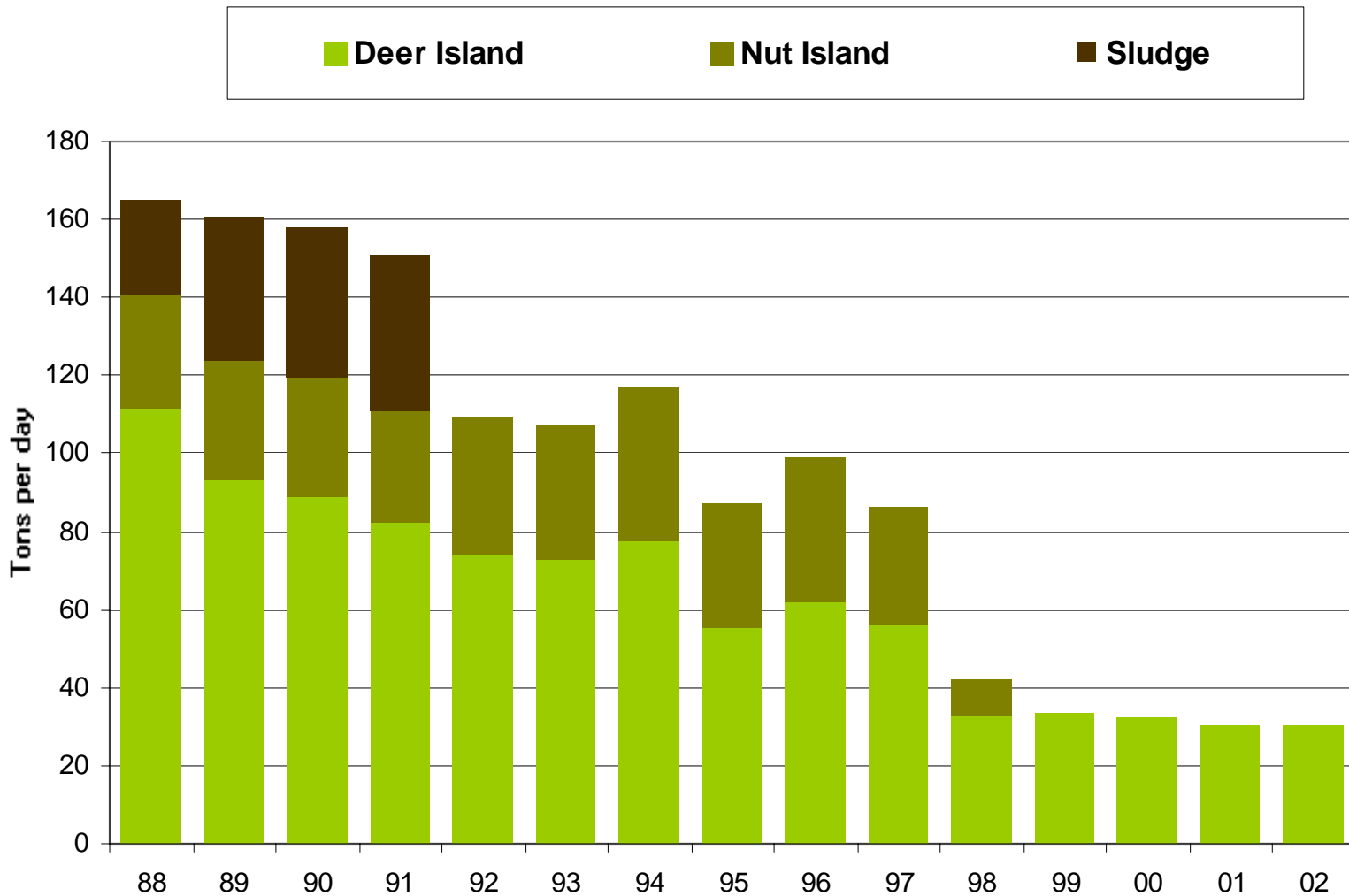


MWRA primary and secondary treated flows 1990-2002



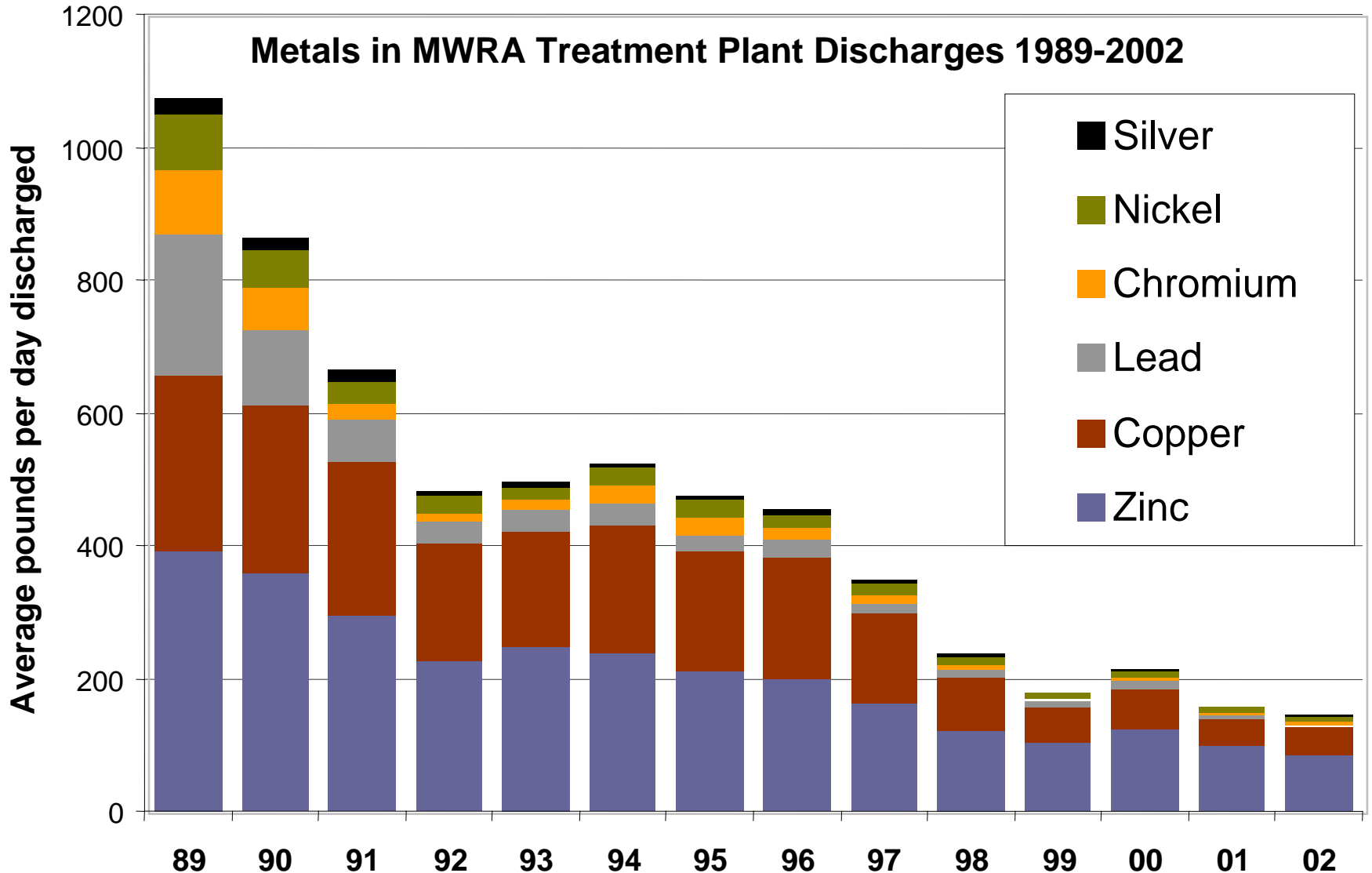


Solids discharged from MWRA sources decreased by 80%



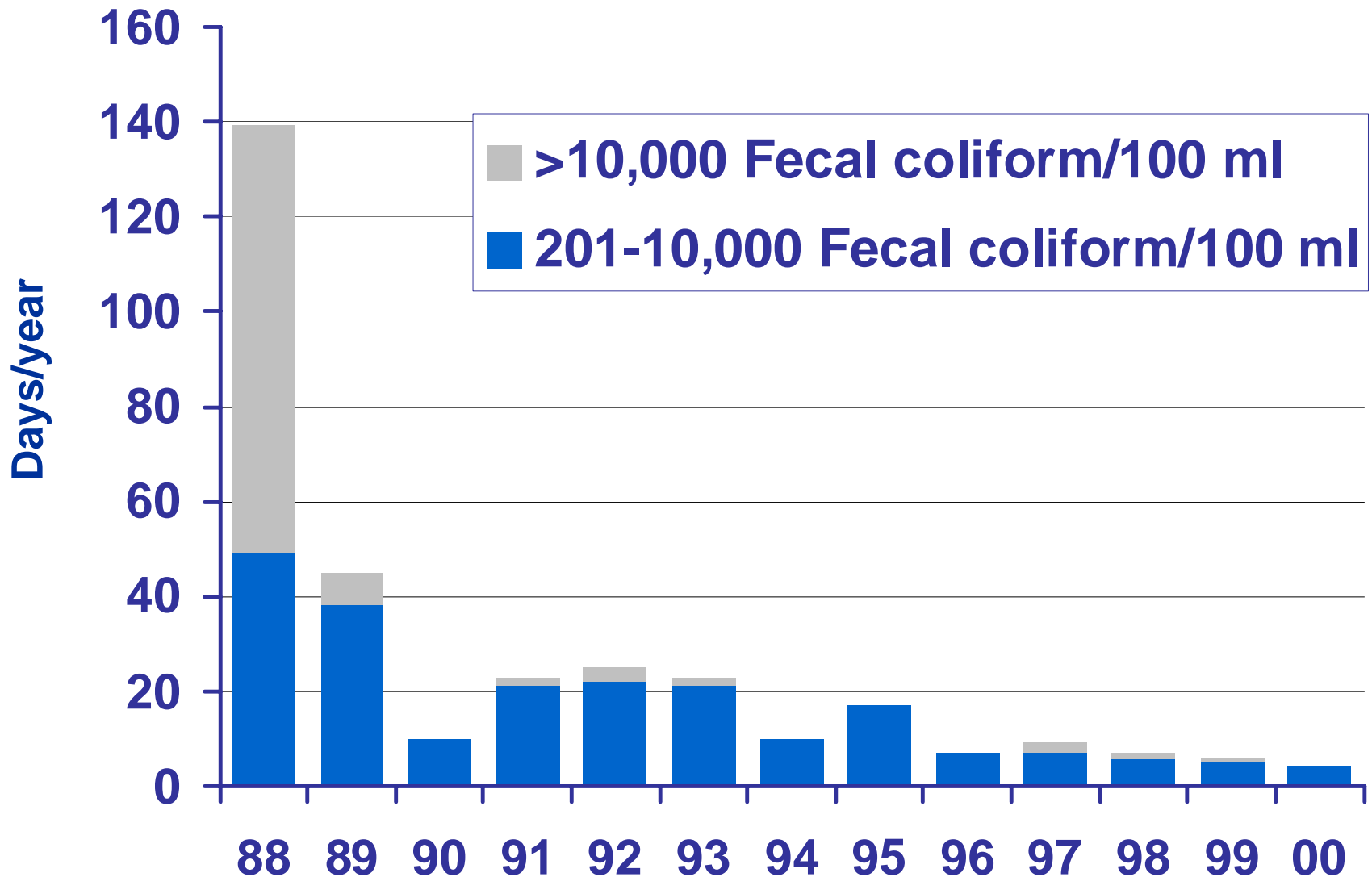


Metals discharges dropped due to the industrial pretreatment program and secondary treatment





Days with high coliform in wastewater dropped early in the BHP





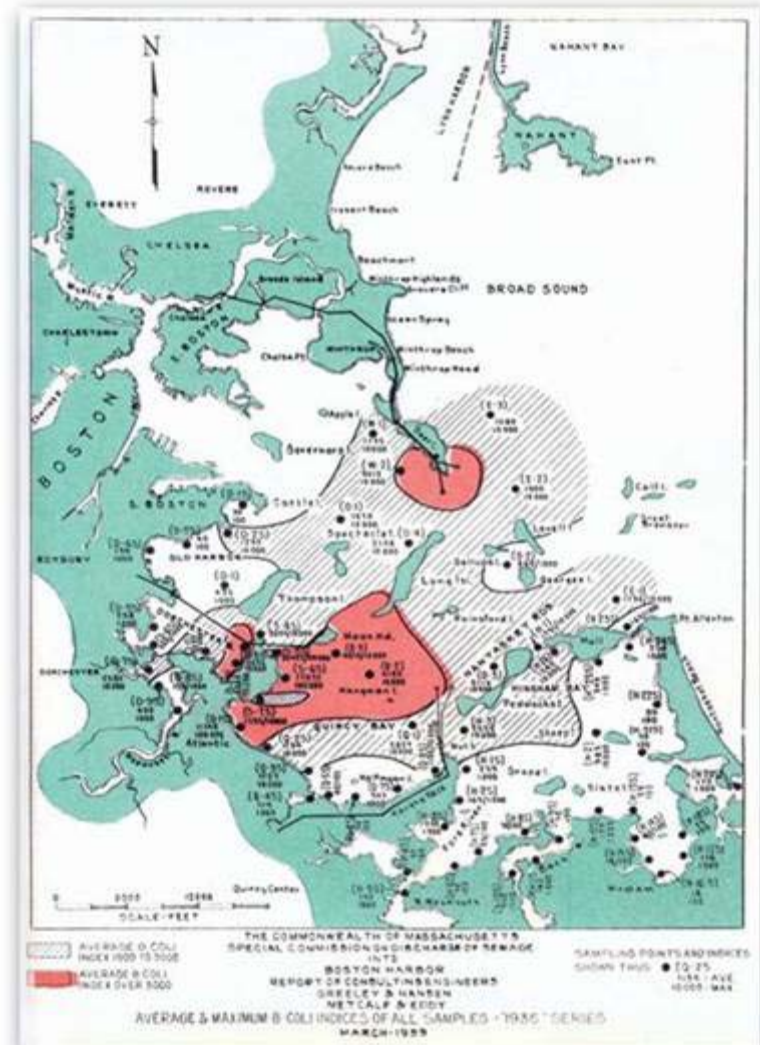
BOSTON HARBOR MONITORING RESULTS





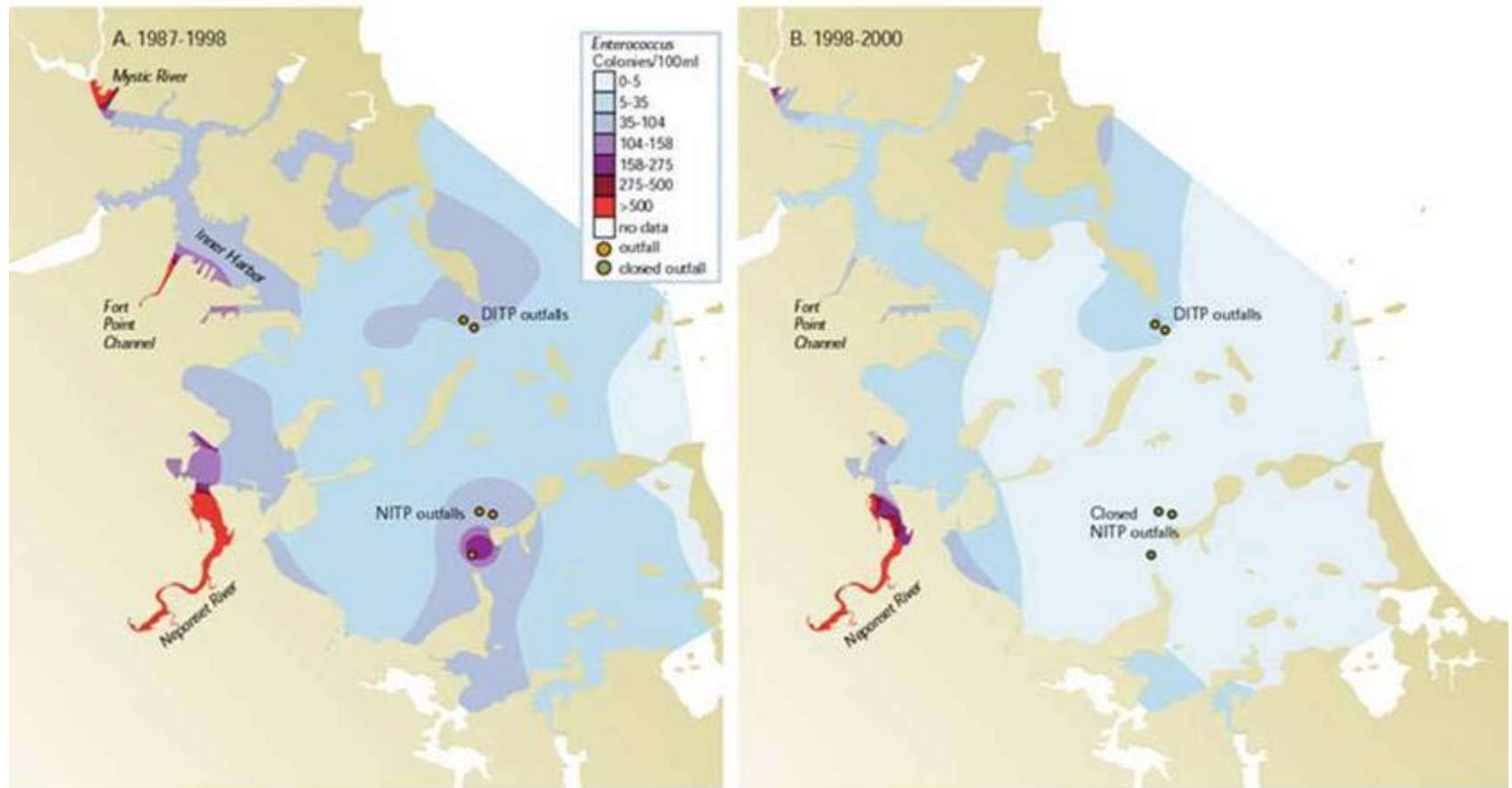
Long history of bacteria contamination in harbor

1939 report shows large areas of coliform counts exceeding 3,000 col/100 ml near the Deer Island and Moon Island discharge sites



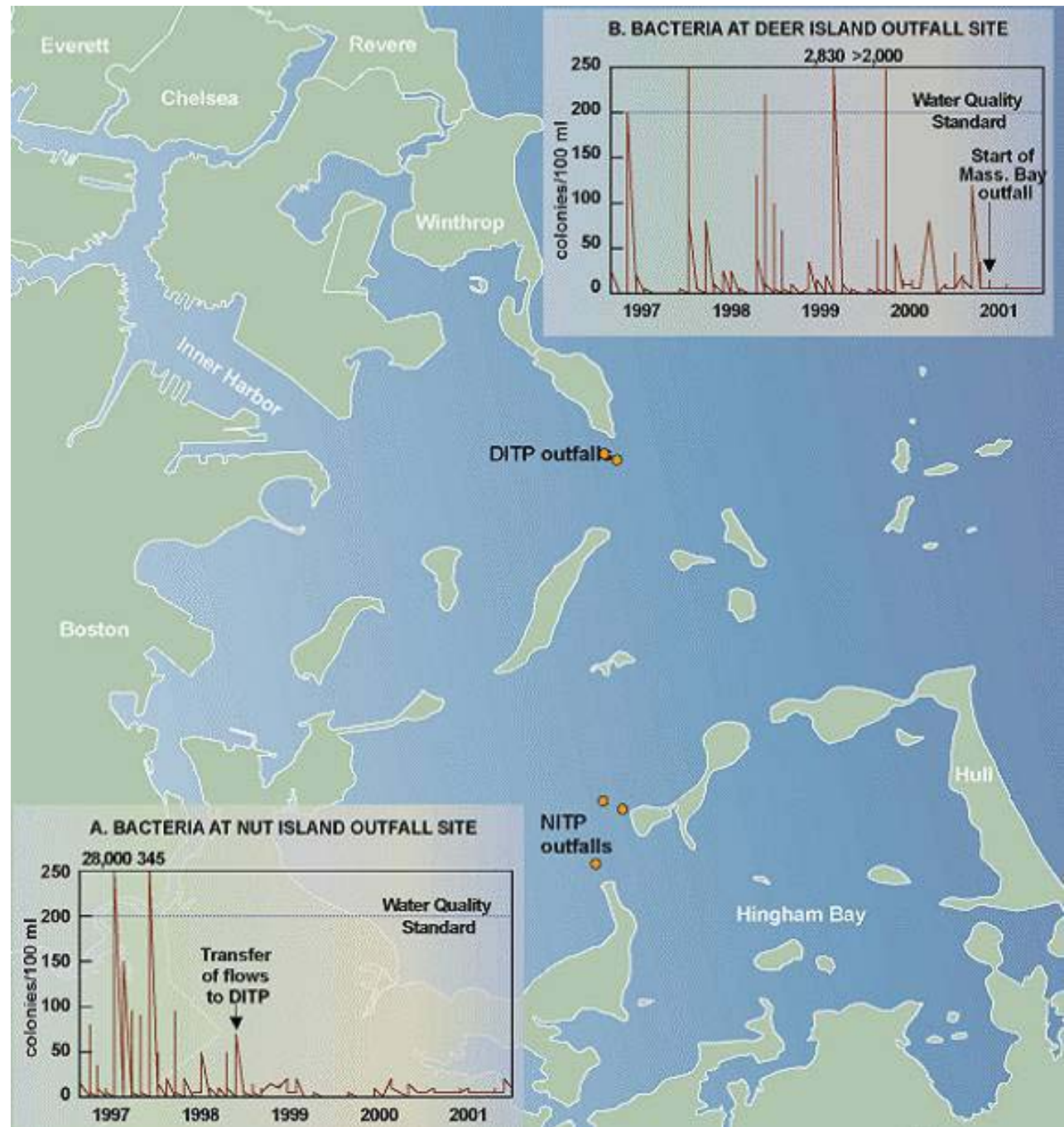


Average *Enterococcus* in Boston Harbor changed dramatically between 1987-1998 and 1998-2000



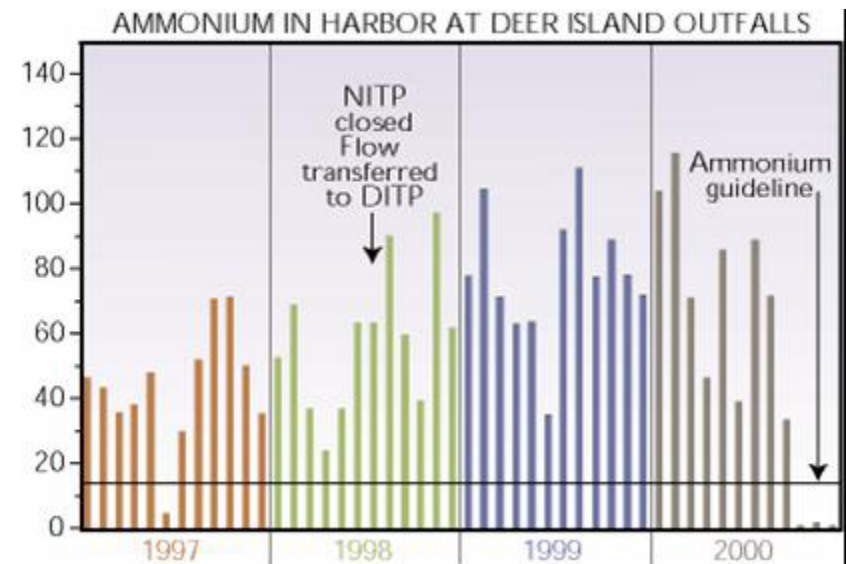
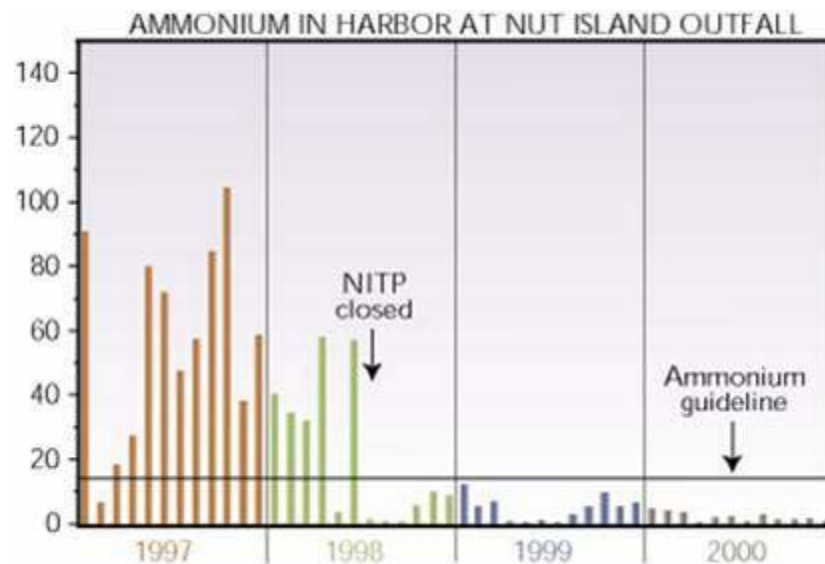


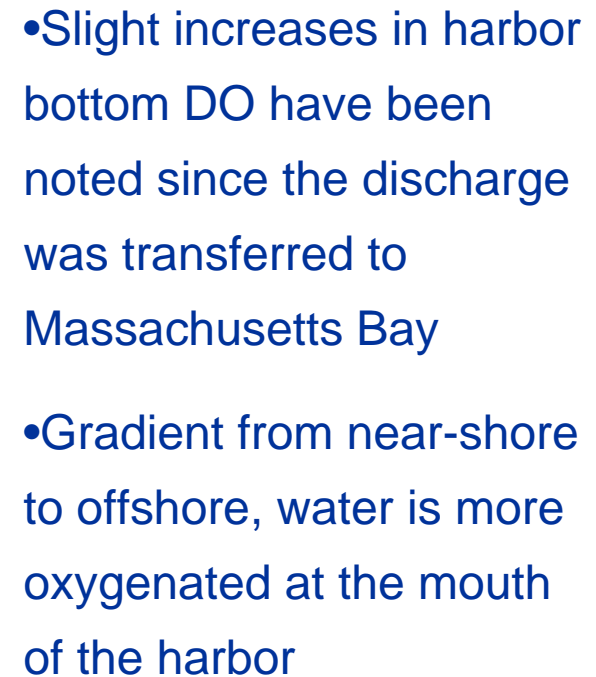
- Bacteria counts dropped near harbor outfall sites when discharges ended
- First at Nut Island, then Deer Island





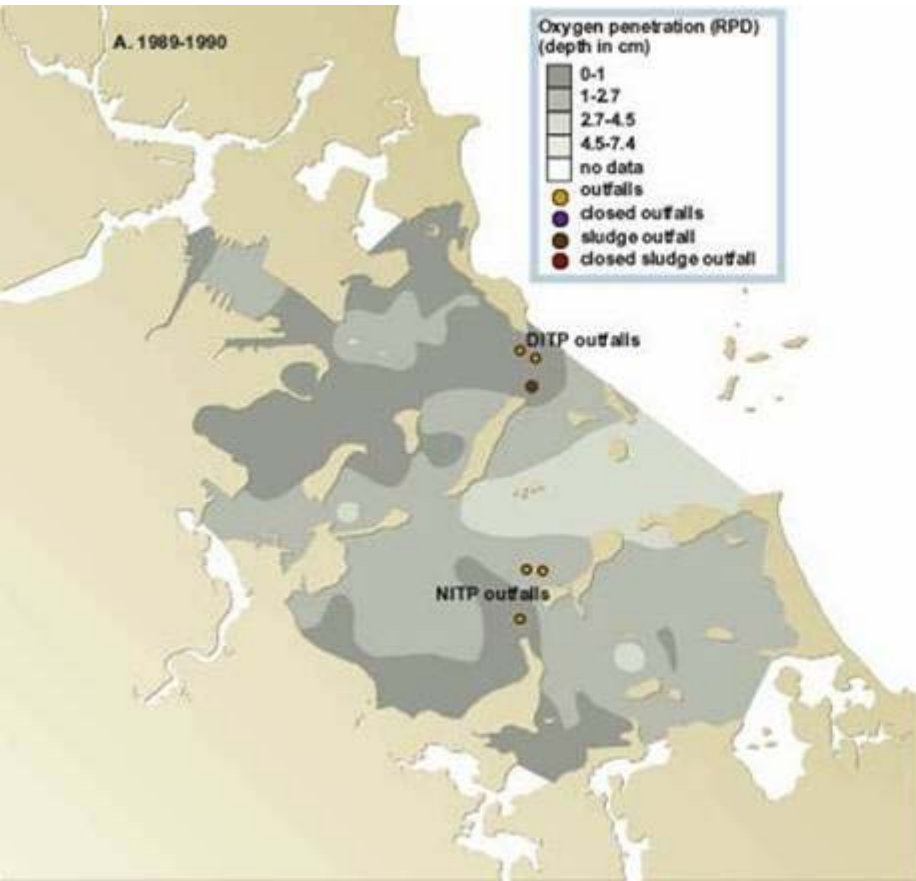
Nutrient levels near Nut Is. then Deer Is. decreased when the discharges stopped, now show natural seasonal cycle







Sediment oxygenation has significantly increased, especially in the central and northern harbor



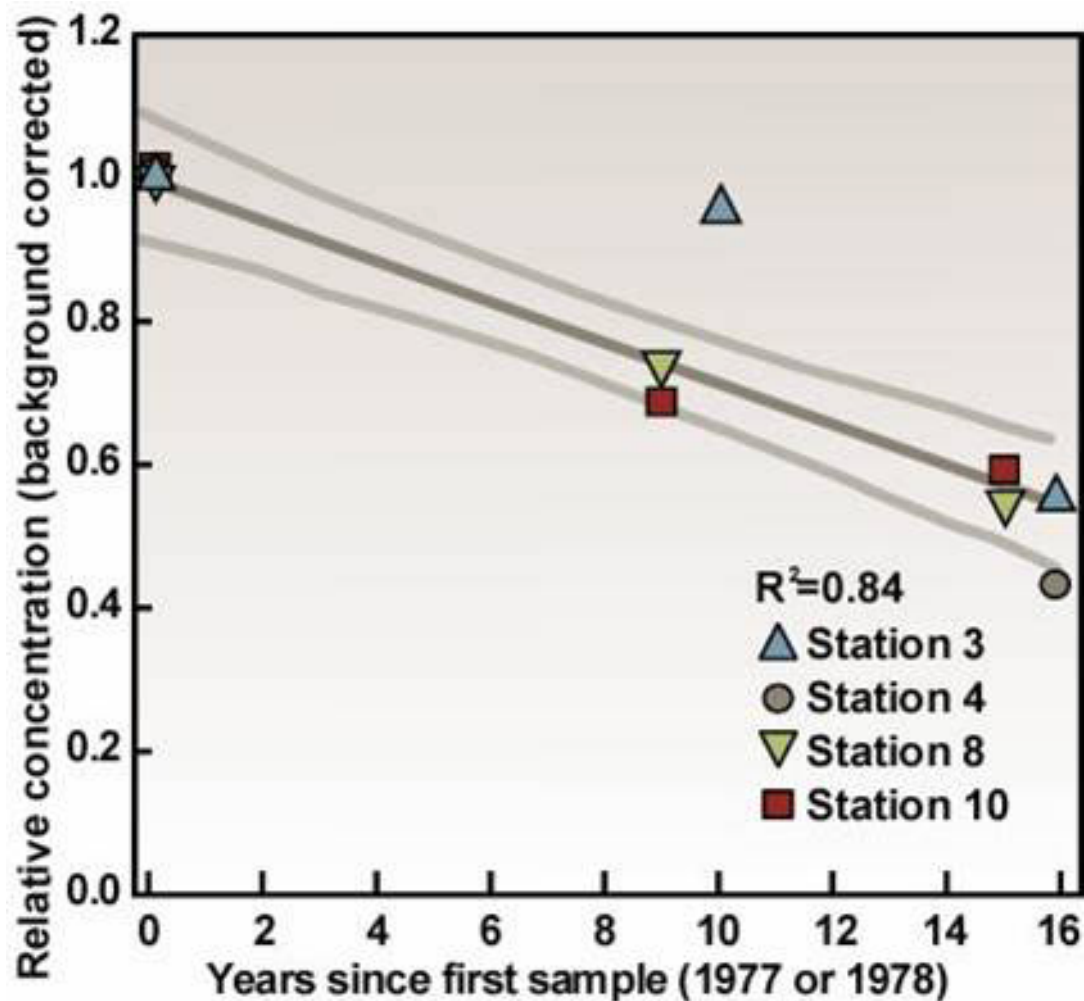


USGS long-term sediment contaminant study



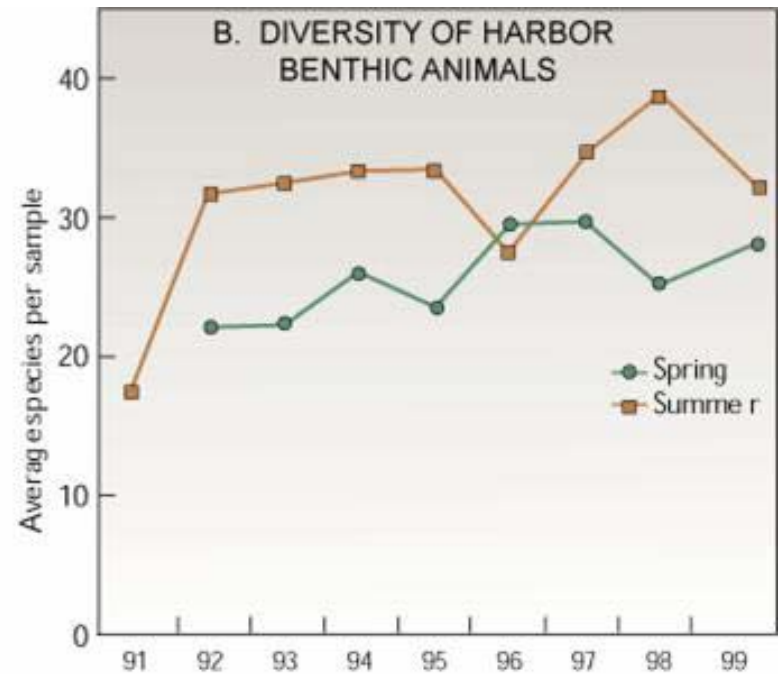
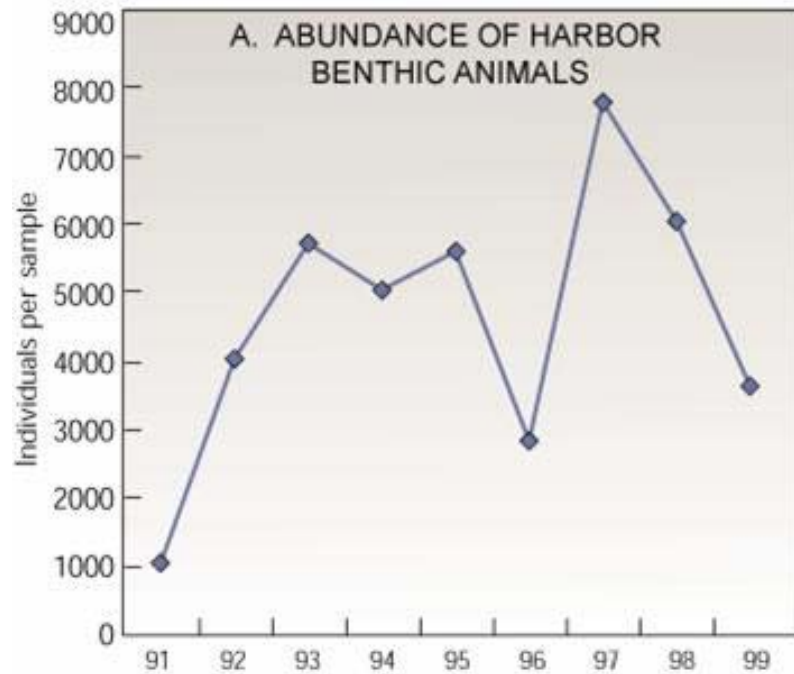


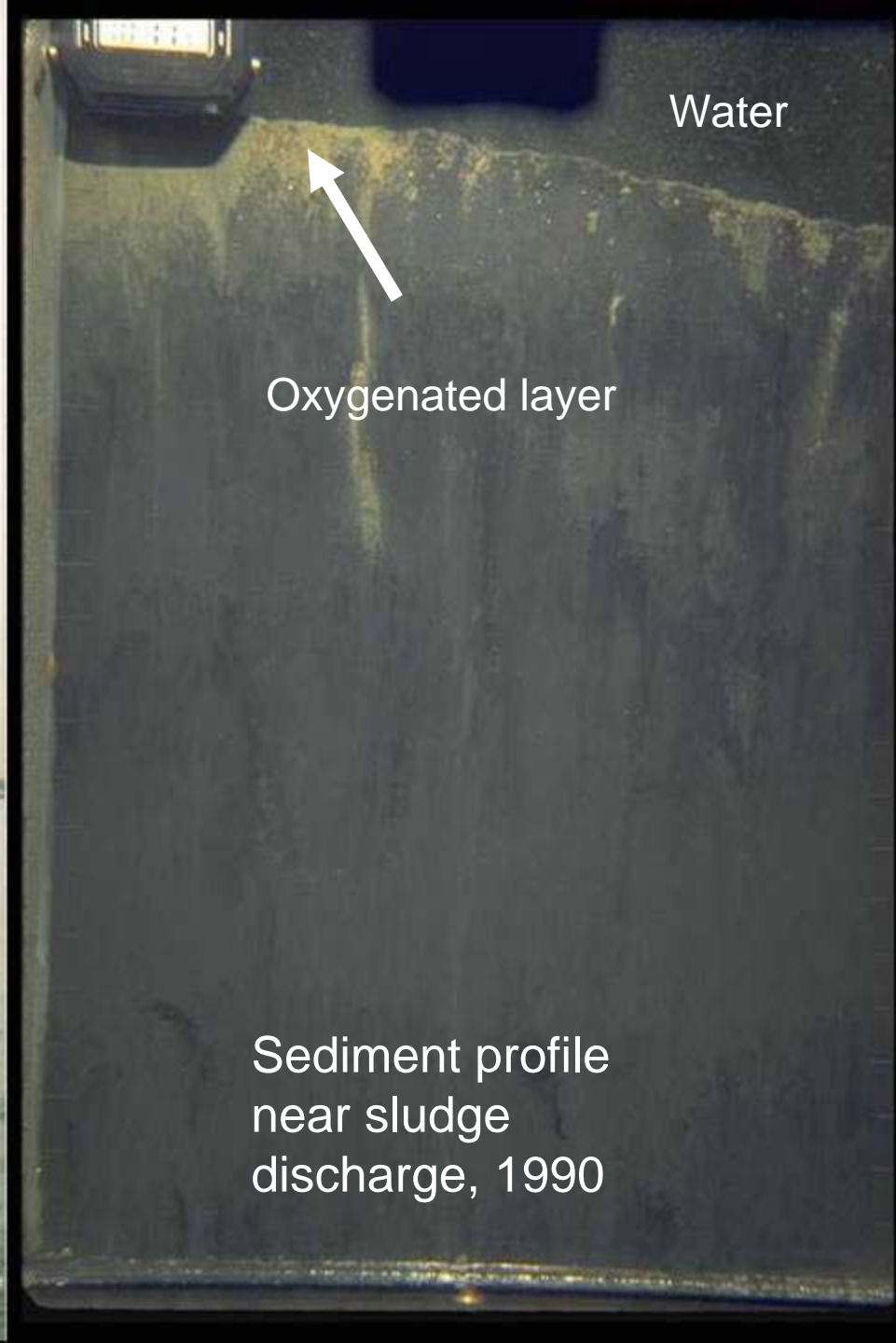
USGS finds decreases in lead and other metals





Animals in the sediments: Increases in both abundance and diversity





Water

Oxygenated layer

Sediment profile
near sludge
discharge, 1990



Ampelisca tube mats

Cross section near former sludge site, 1996



Average contaminants in mussels deployed at Harbor outfall site: 1991-2001



- Mussels were caged at the outfall site for 60 days, then analyzed for suite of toxic contaminants
- Contaminants are well below FDA limits

Parts per billion, wet weight		
	Actual range of annual averages	FDA limit
PCBs	14.9 - 36.6	2,000
DDT	2.2 - 8.3	5,000
PAH-low molecular weight (ng/g dry)	38 - 528	None



Is the Harbor improving at the expense of Massachusetts Bay?



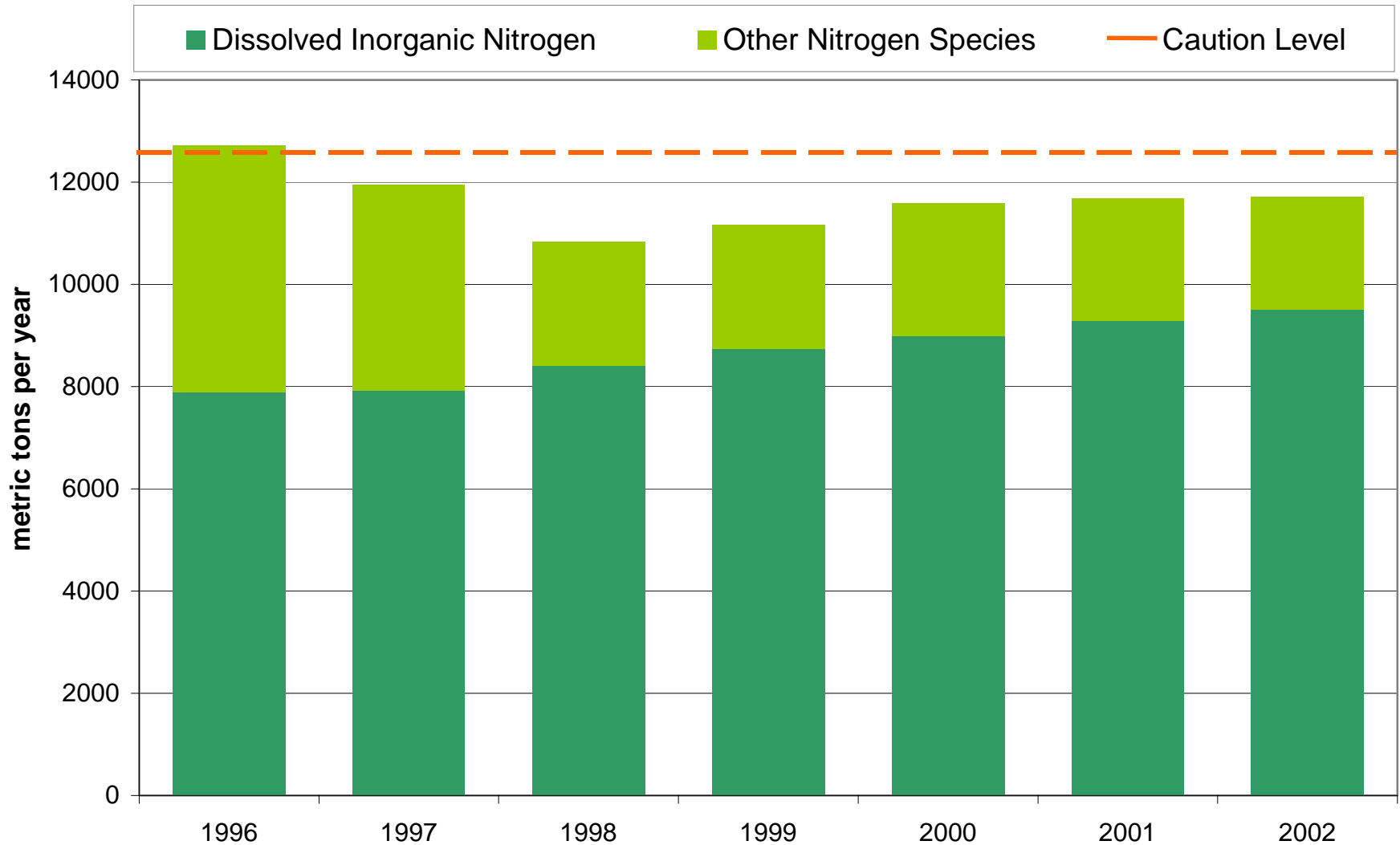


MONITORING THE NEW OUTFALL IN MASS. BAY





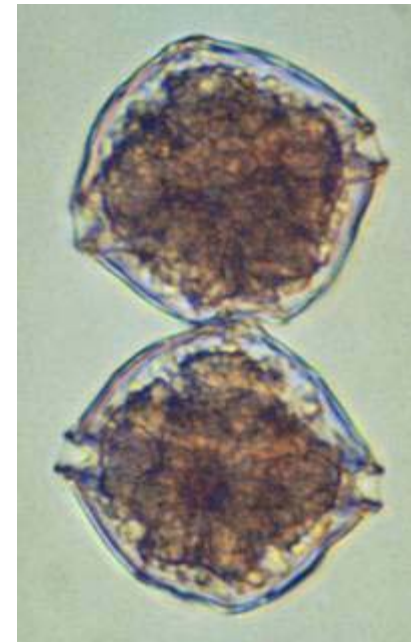
Changes in MWRA nitrogen discharges





Nutrient effects questions in bay

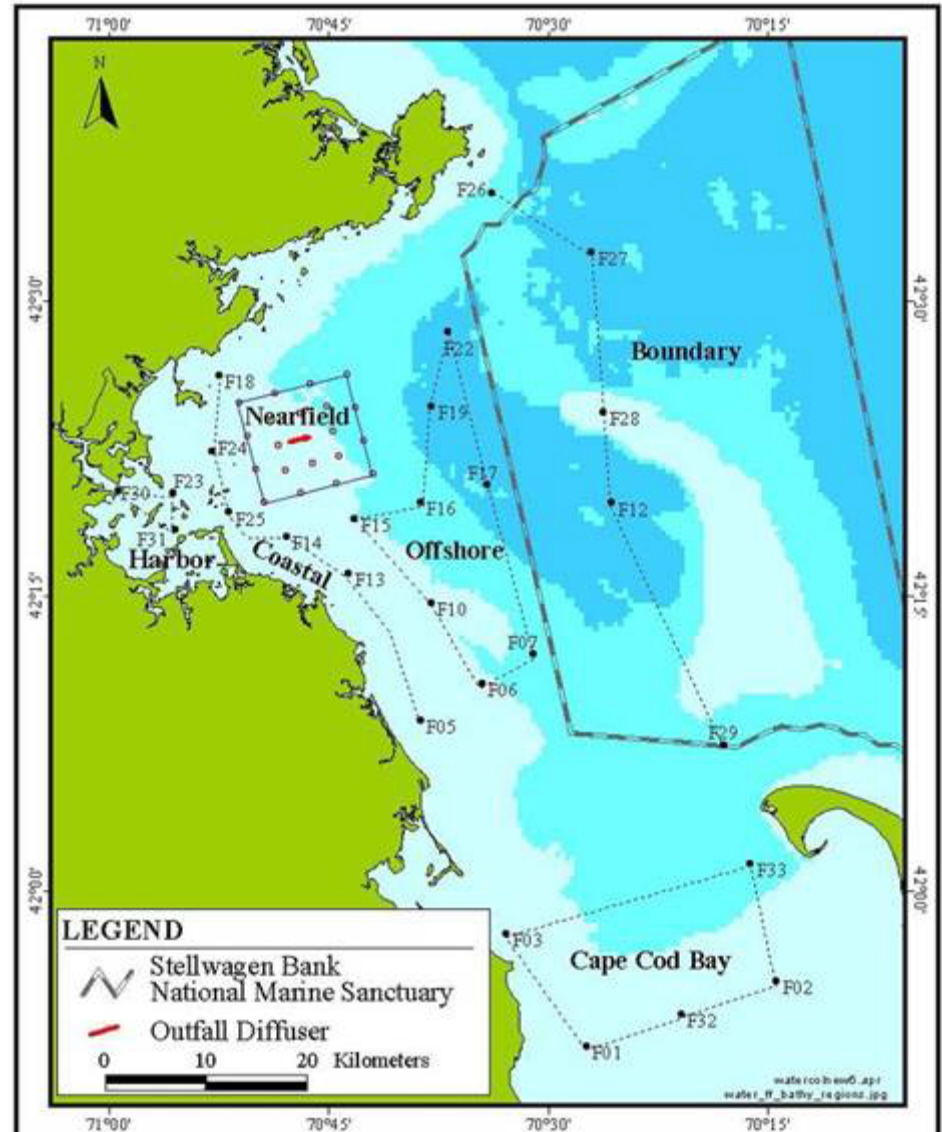
- **Eutrophication-excess algal growth?**
- **Effect on dissolved oxygen?**
- **Harmful algal blooms?**
 - **Alexandrium (PSP)**
 - **Pseudonitzschia (ASP)**
 - **Phaeocystis**
- **Ecosystem**
 - **phytoplankton species composition**
 - **changes in timing, extent of blooms**





Outfall monitoring: water column

- Water quality measured in six regions:
 - Harbor
 - Coastal
 - Nearfield
 - Offshore
 - Cape Cod Bay
 - Boundary





Water column monitoring: many parameters

- nutrients
- chlorophyll
- dissolved oxygen
- temperature, salinity
- light, water clarity
- solids
- phytoplankton
- nuisance and noxious algae
- zooplankton
- photosynthesis, respiration
- remote sensing, moored instruments
- marine mammal observations
- bacterial indicators, viruses
- diffuser mixing

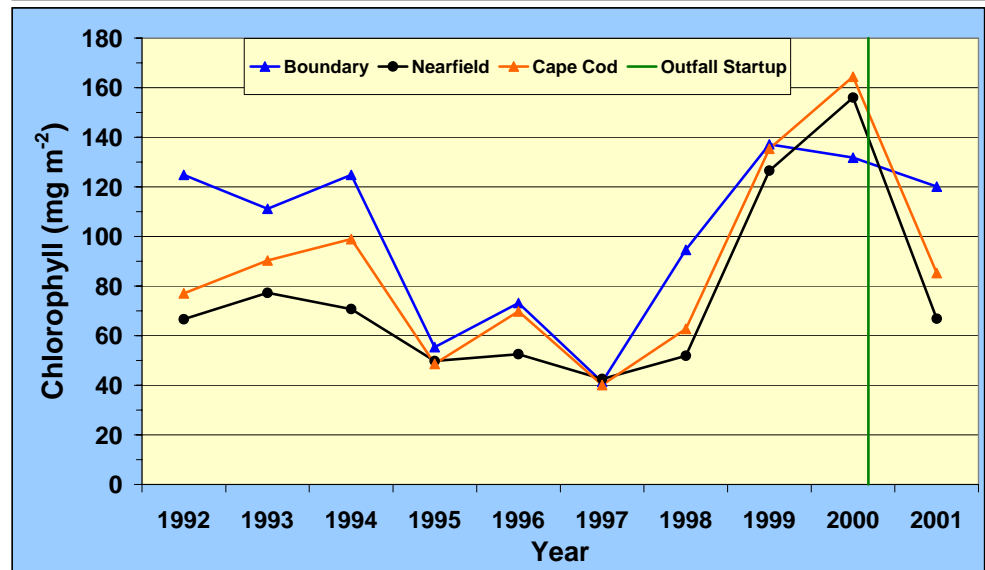
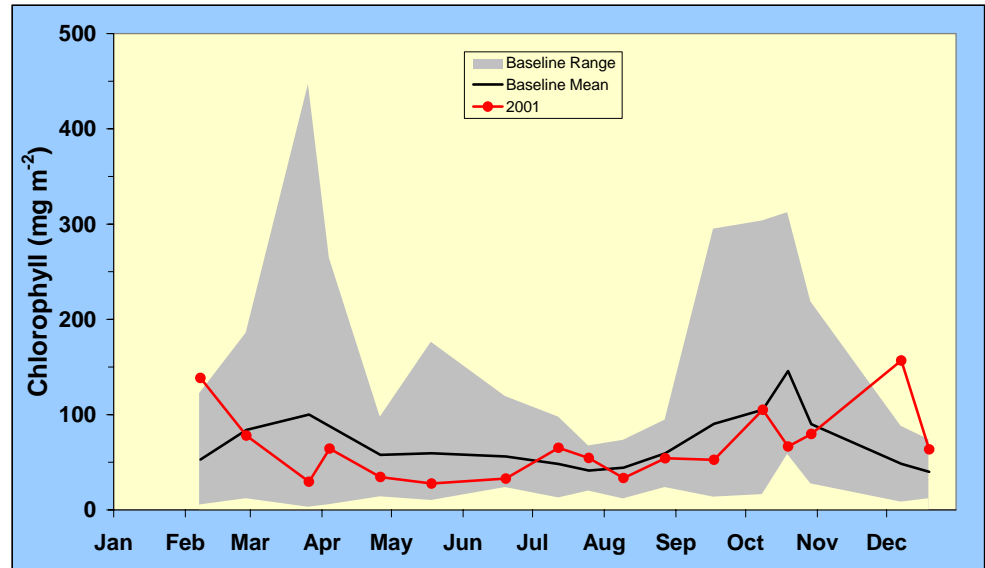


Water sampling “rosette”



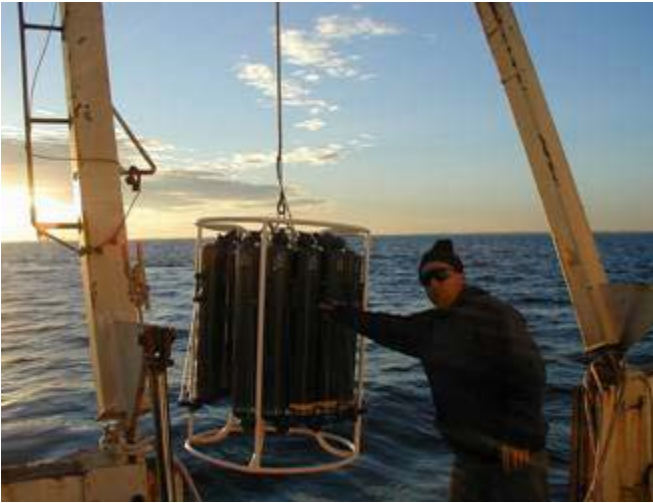
Outfall monitoring 2001 water quality chlorophyll

- Chlorophyll, a measure of phytoplankton biomass, showed no response to nutrient enrichment of the outfall, even in the nearfield.

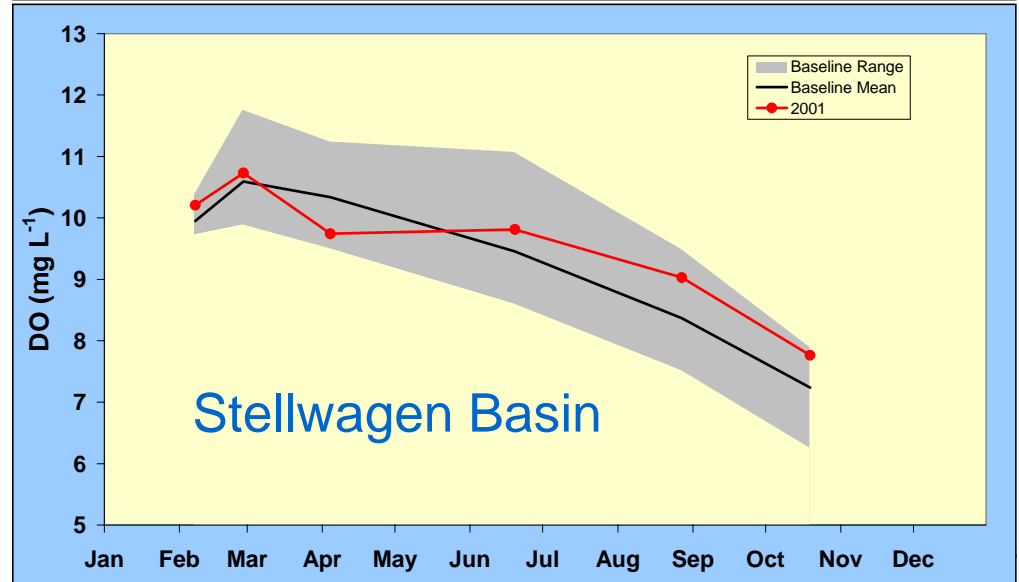
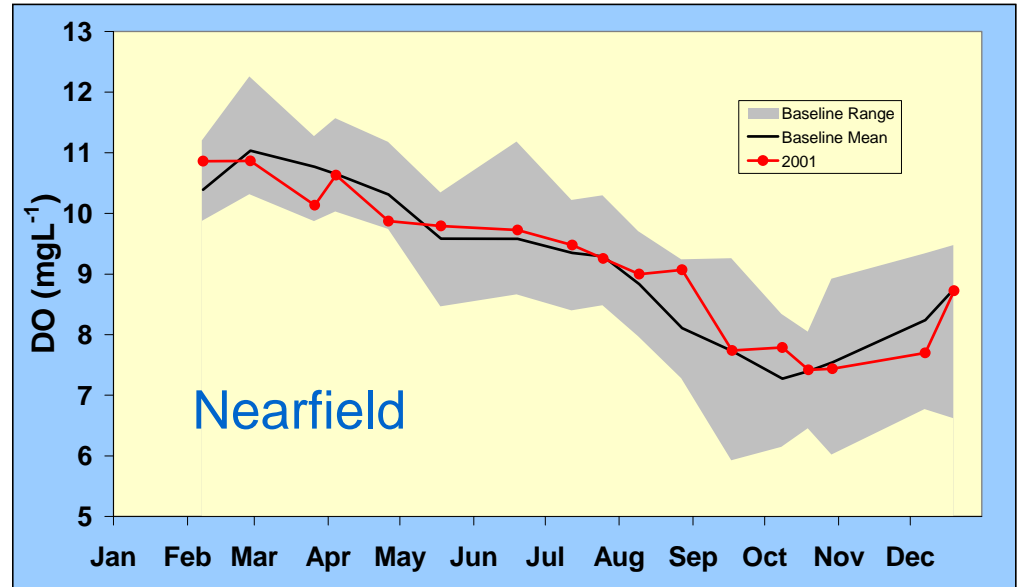




Outfall monitoring 2001 dissolved oxygen

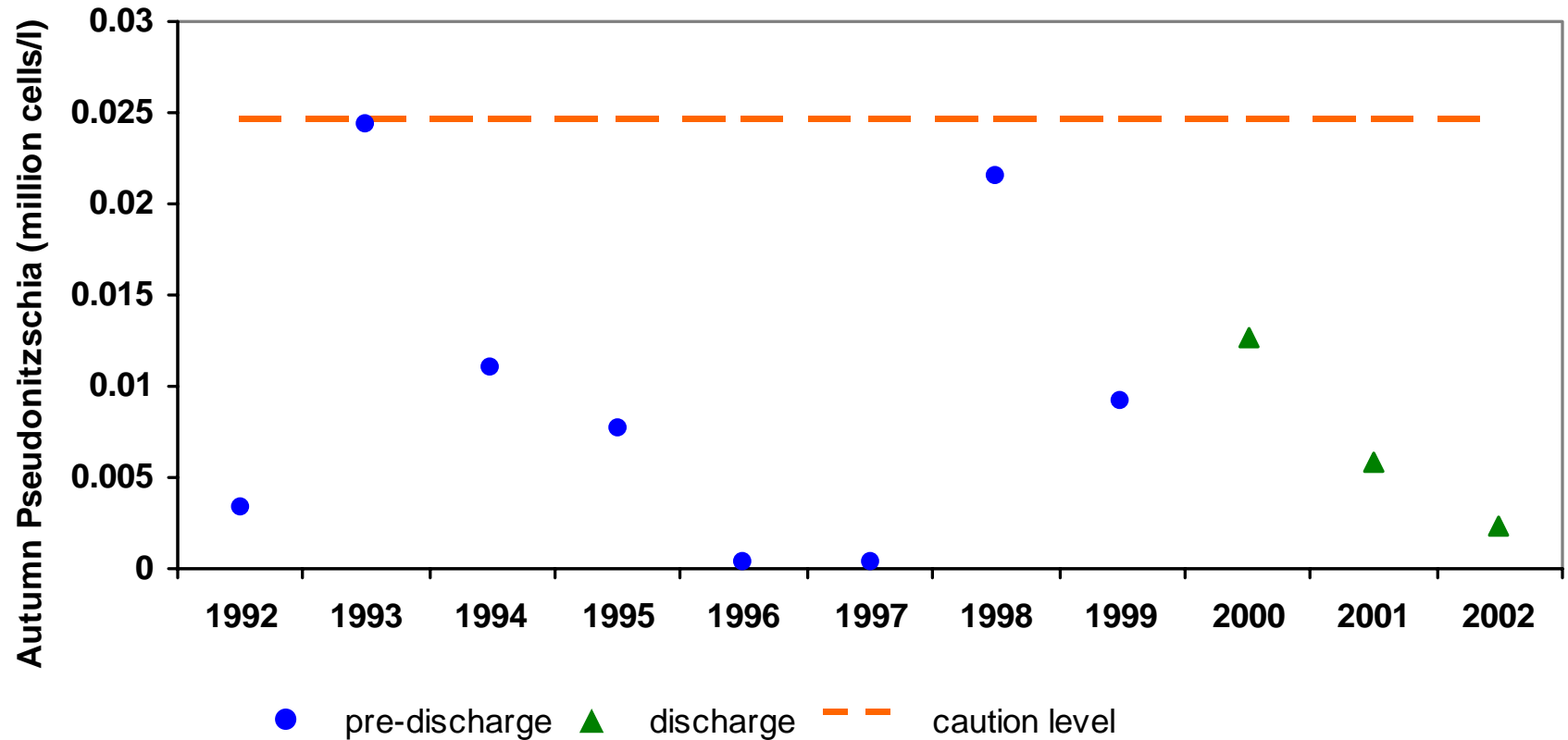


- Dissolved oxygen remained in the range of the baseline, and very close to the baseline mean





Autumn *Pseudonitzschia* abundances near outfall 1992-2002

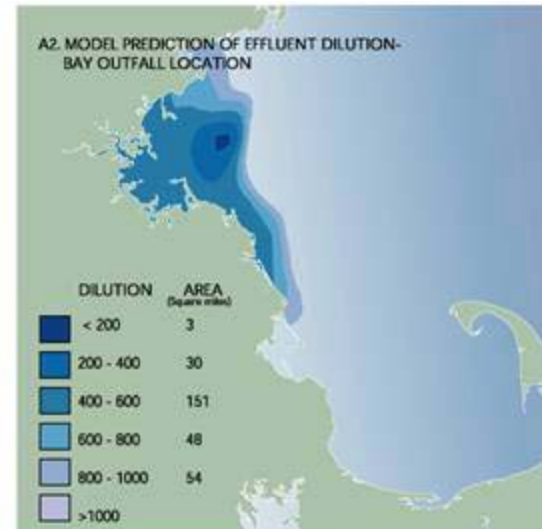
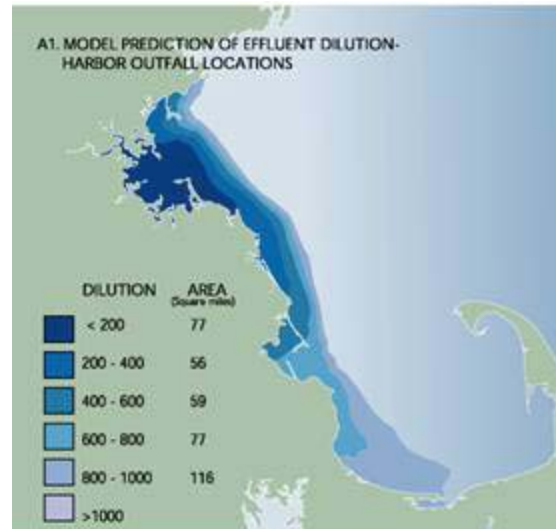




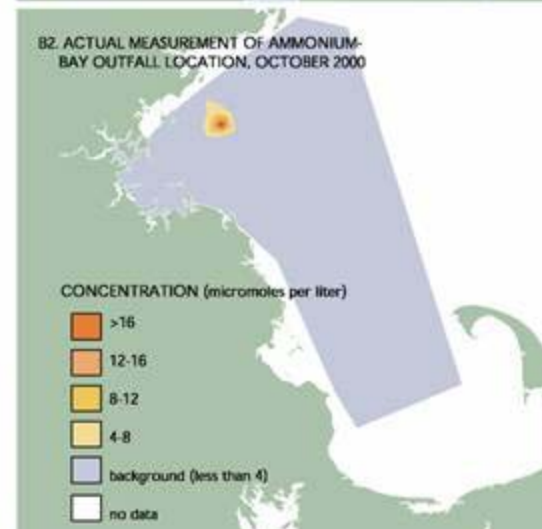
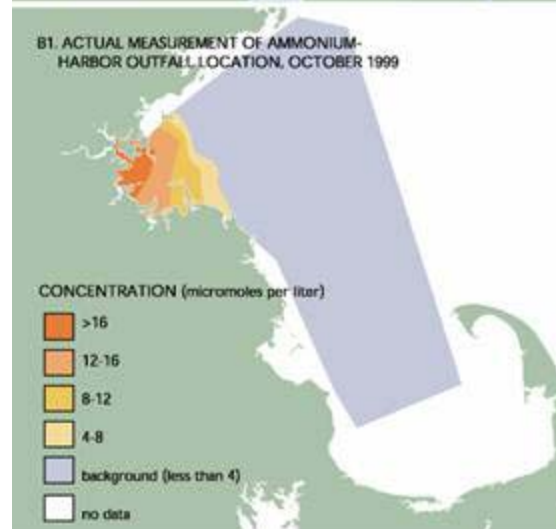


Massachusetts Bay model compared to data

Model



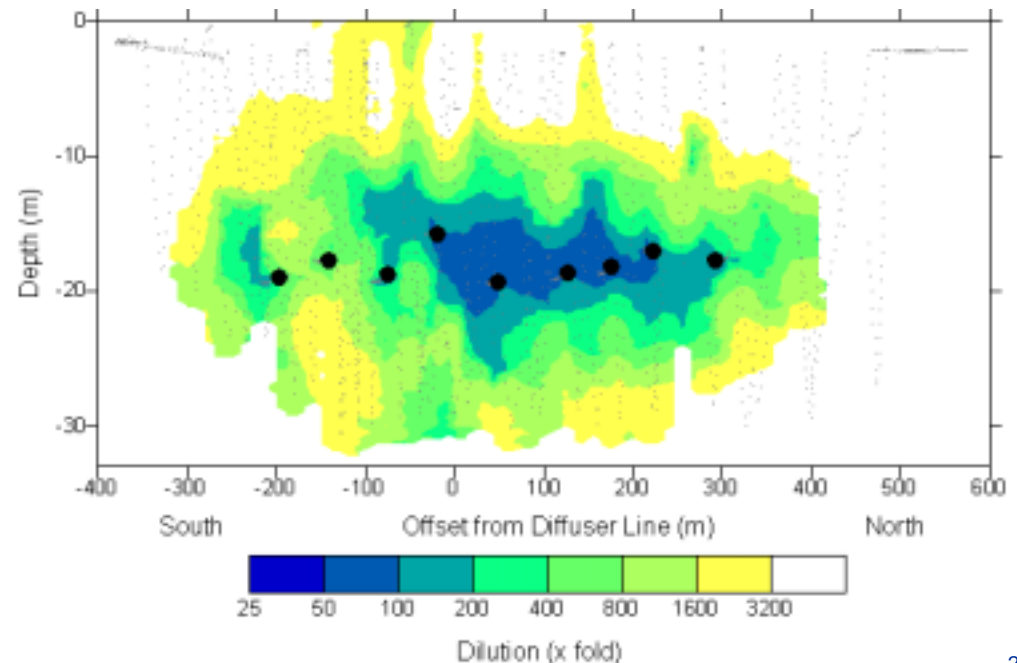
Ammonium
measurements





Outfall certification: Dye dilution study

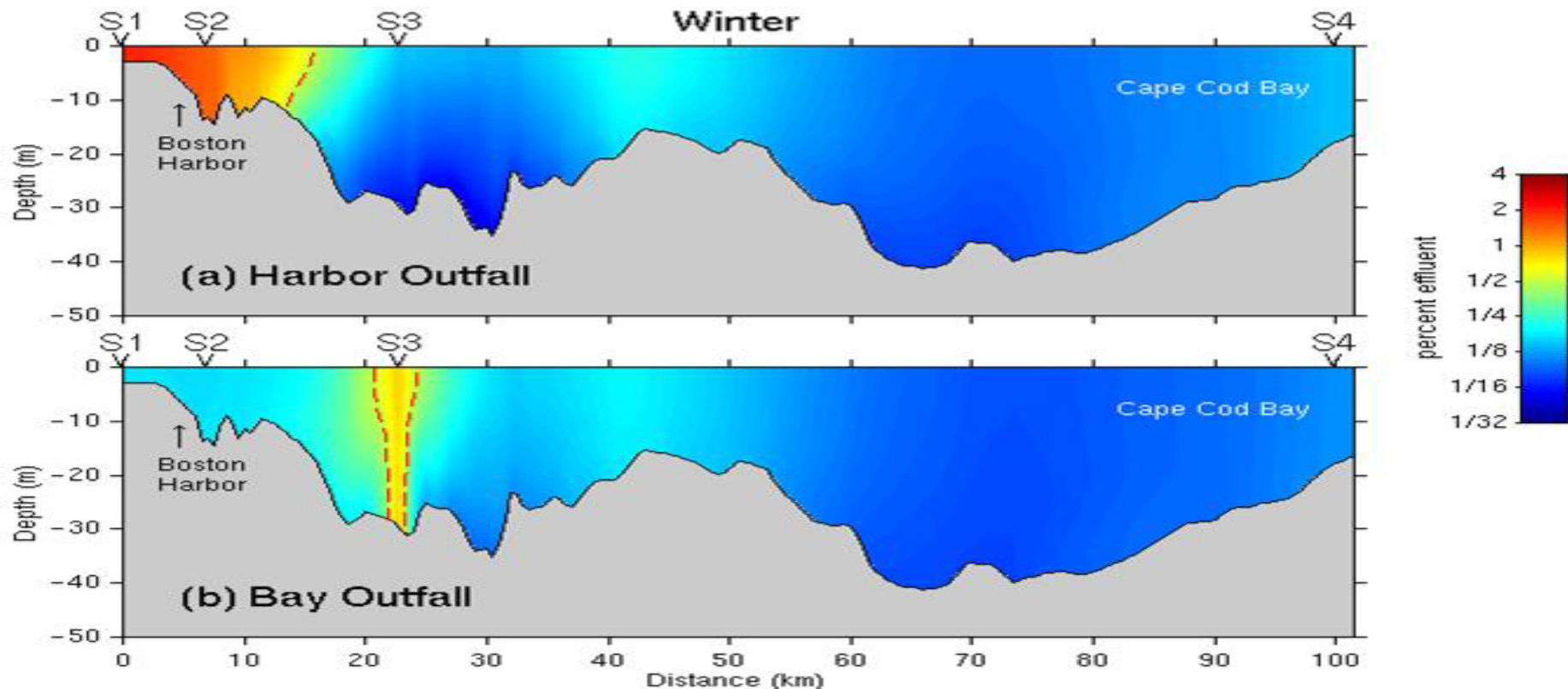
- Purpose: to measure dilution at the edge of the hydraulic mixing zone
- Result: outfall dilution was consistent with model predictions of approximately 1:70
- Regulators approved certification October 2002





Hydrodynamic modeling of effluent plume dilution: Winter Hydrographic section, Boston Harbor outfall to Cape Cod Bay

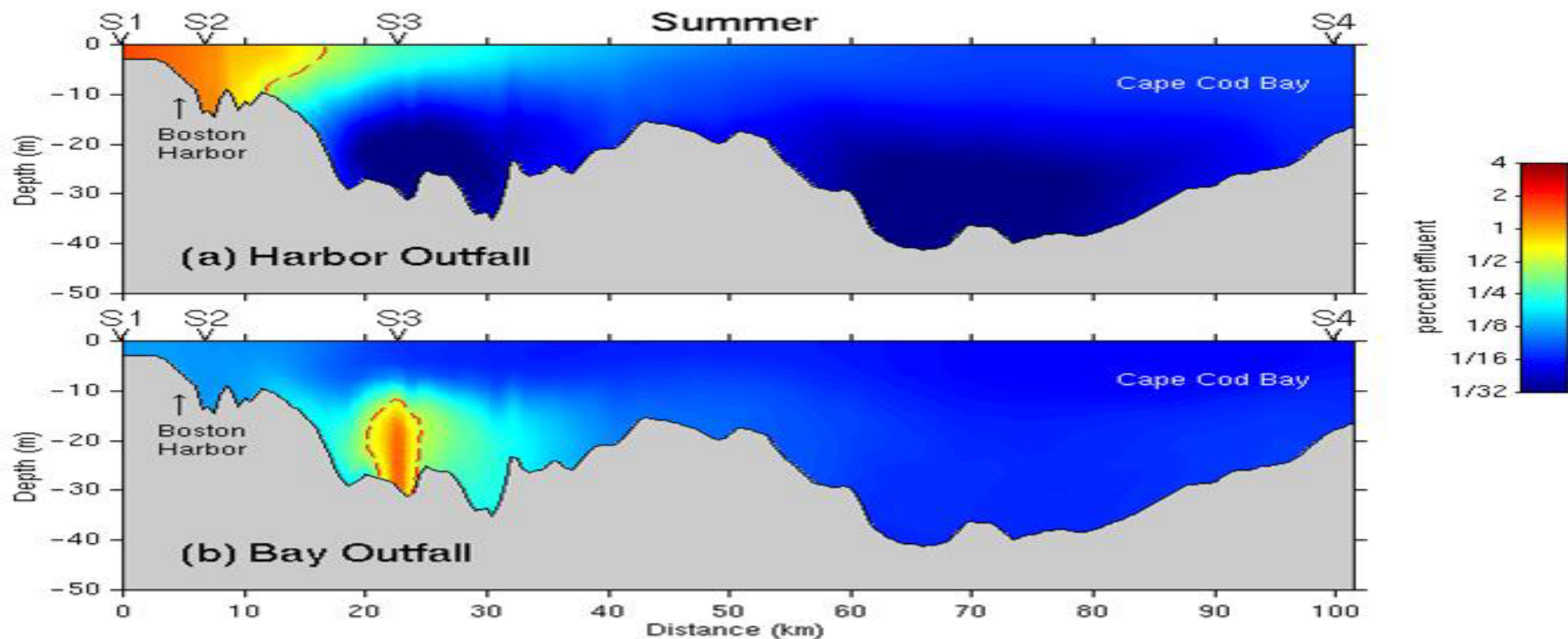
- Higher concentrations with old outfall, mainly in Boston Harbor
- Farfield dilution virtually the same when outfall is online
- Effluent will extend to surface in dilute concentrations from new outfall during winter, due to absence of stratification





Hydrodynamic modeling of effluent plume dilution: Summer Hydrographic section, Boston Harbor outfall to Cape Cod Bay

- Effluent from Harbor location trapped in surface layer in summer
- Effluent from new outfall trapped below thermocline in summer
- Difference likely to reduce impact of nutrient loading from outfall on ecosystem









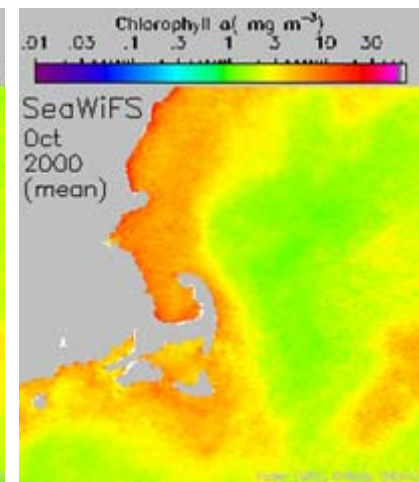
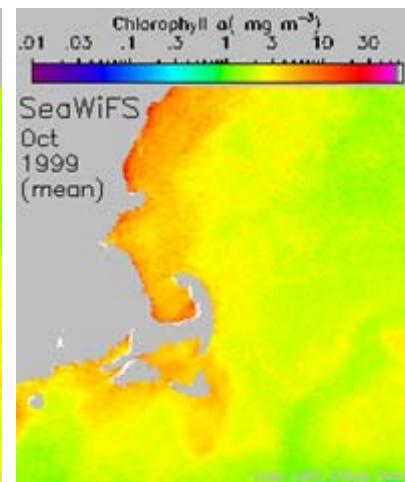
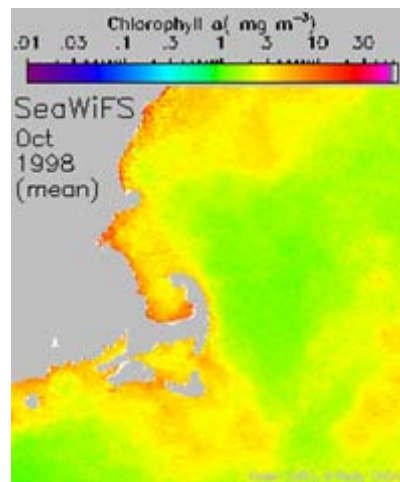
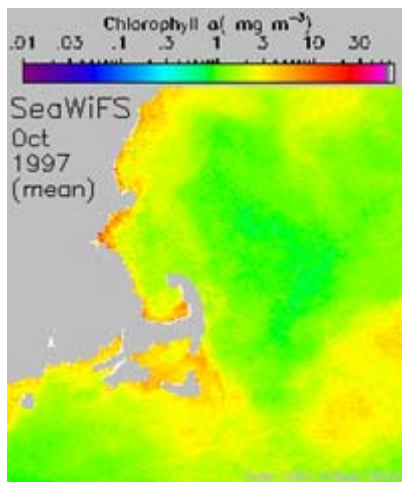
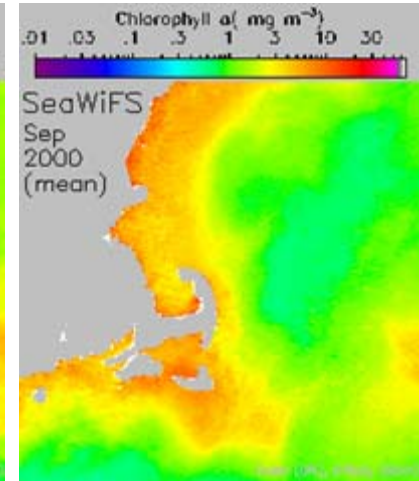
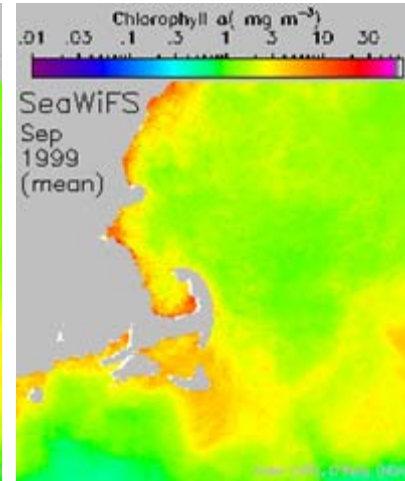
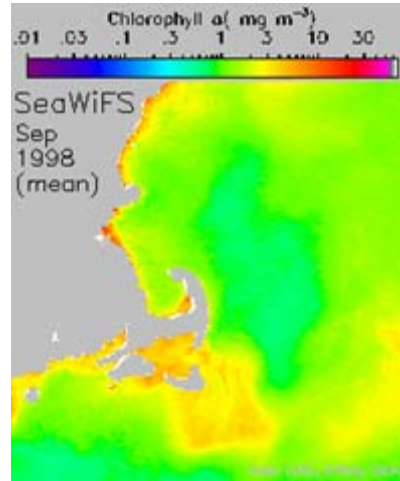
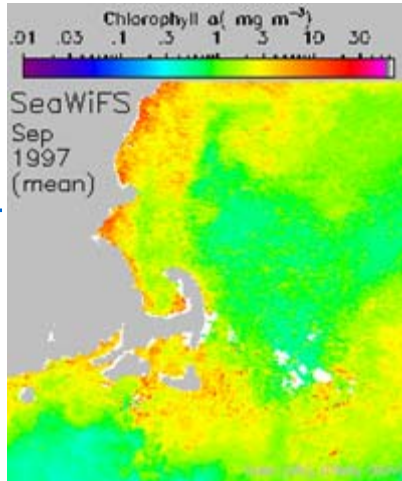
Satellite data show trends in broad spatial scale, like chlorophyll levels in GoM and south of Cape Cod

1997

1998

1999

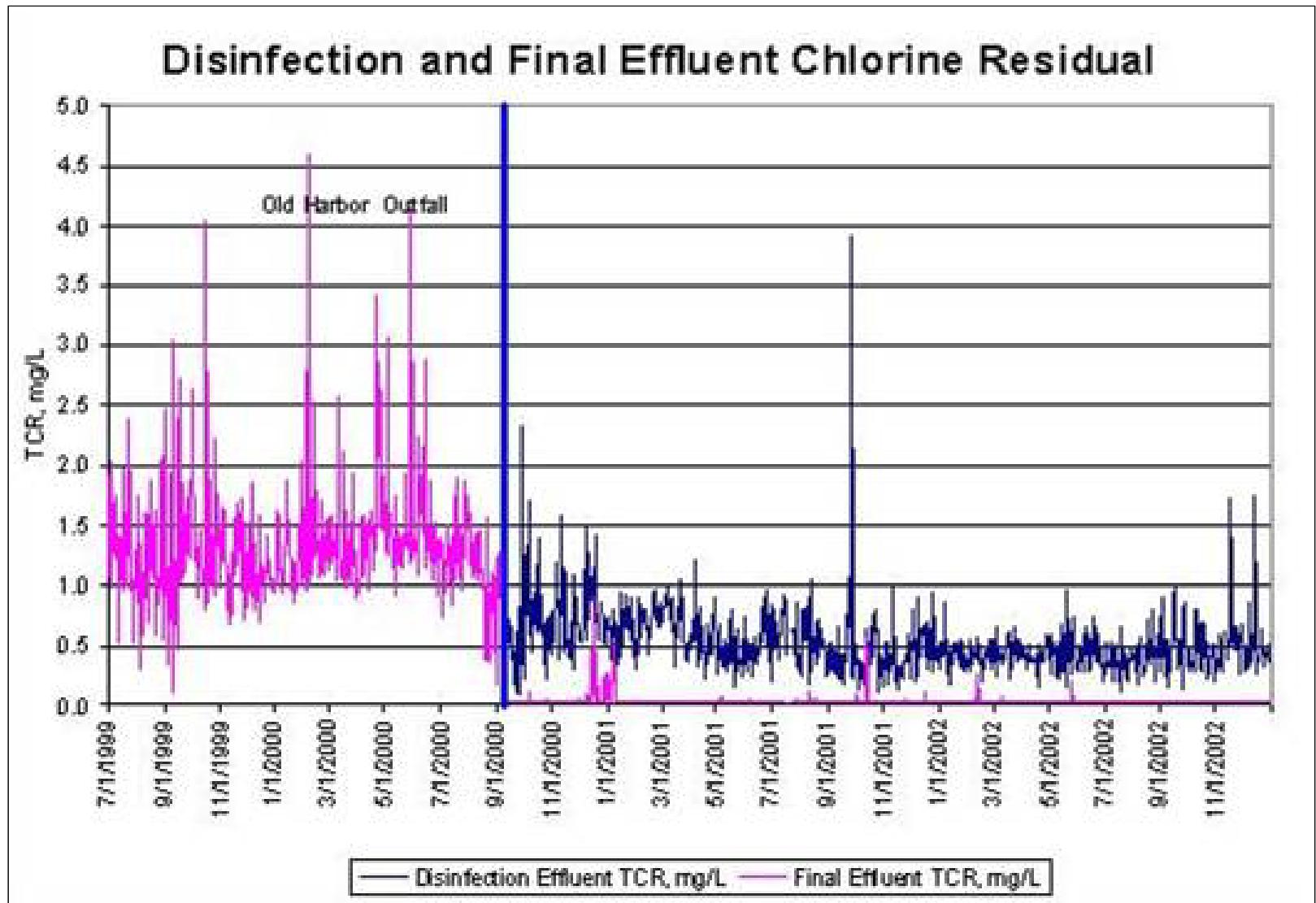
2000



J. Yoder (URI), J.O'Reilly (NOAA)



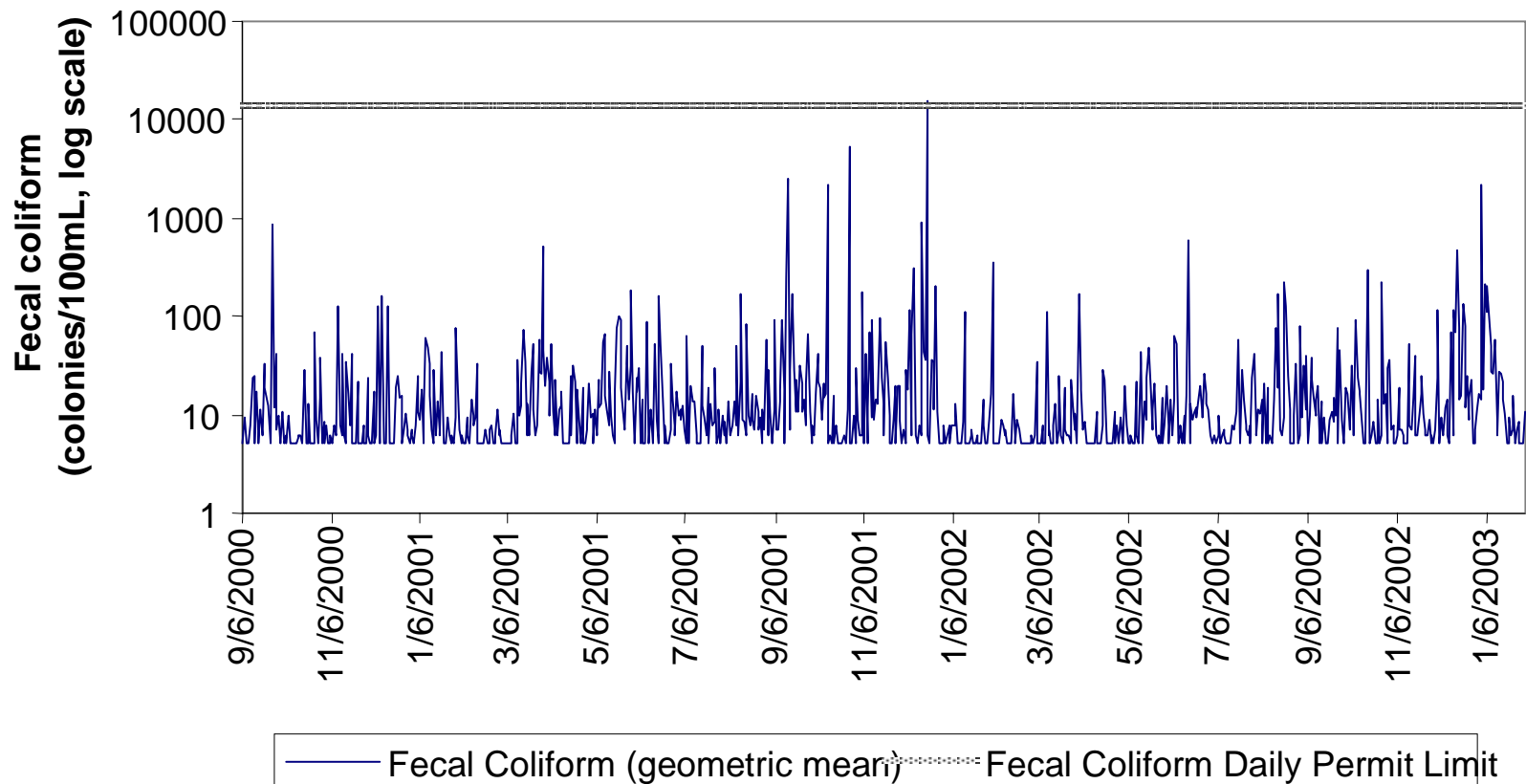
Total chlorine residual dropped when dechlorination went into operation





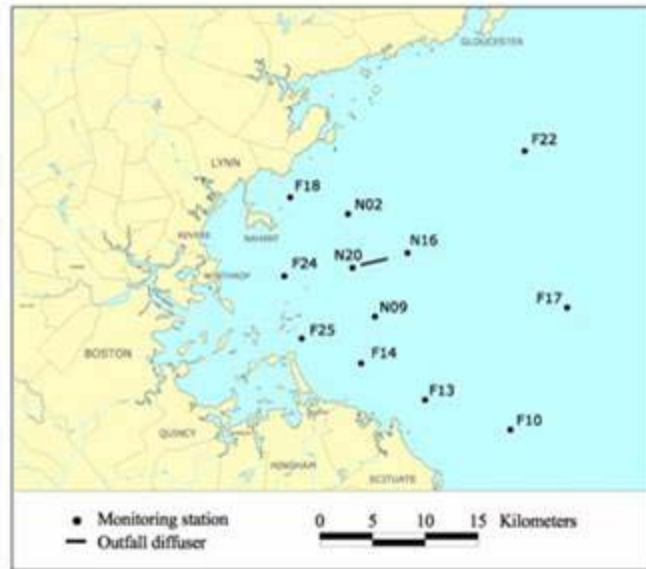
Outfall dilution is 70-fold; MWRA's effluent fecal coliform limit is 14,000 col/100 ml

Bacteria data since new outfall went on-line





Monthly bacteria monitoring around outfall



	Geometric mean bacteria counts (colonies/100 ml) at new outfall site	
	Fecal coliform	<i>Enterococcus</i>
Before outfall start-up	2.0	1.0
After outfall start-up	2.2	1.1

- Bacteria are sampled monthly, at surface and subpycnocline
- Slight increase observed immediately above new outfall



Monthly outfall site bacteria monitoring posted at mwra.com/harbor/html/whatsnew.htm

Massachusetts Bay bacteria counts

Date	Station	Fecal coliform	Enterococcus
February 20, 2003	F25S	2	1
	F14S	<2	<1
	N09S	<2	2
	F13S	<2	<1
	F10S	<2	<1
	F17S	<2	<1
	F22S	<2	<1
	N16S	<2	<1
	N20S	<2	<1
	N02S	<2	<1
	F18S	<2	<1
	F24S	<2	<1

Massachusetts Bay bacteria counts

Note: The March survey was rescheduled to early April because of weather delays.

Date	Station	Fecal coliform	Enterococcus
April 2, 2003	F25S	<2	<1
	N09S	<2	<1
	F14S	<2	<1
	F13S	<2	<1
	F10S	<2	<1
	F17S	<2	<1
	F22P	<2	<1
	F22S	<2	<1
	N16P	<2	<1
	N16S	<2	<1
	N20P	<2	<1
	N20S	<2	<1
	N02P	<2	<1
	N02S	<2	<1
	F18P	<2	<1
	F18S	<2	<1
	F24S	<2	<1



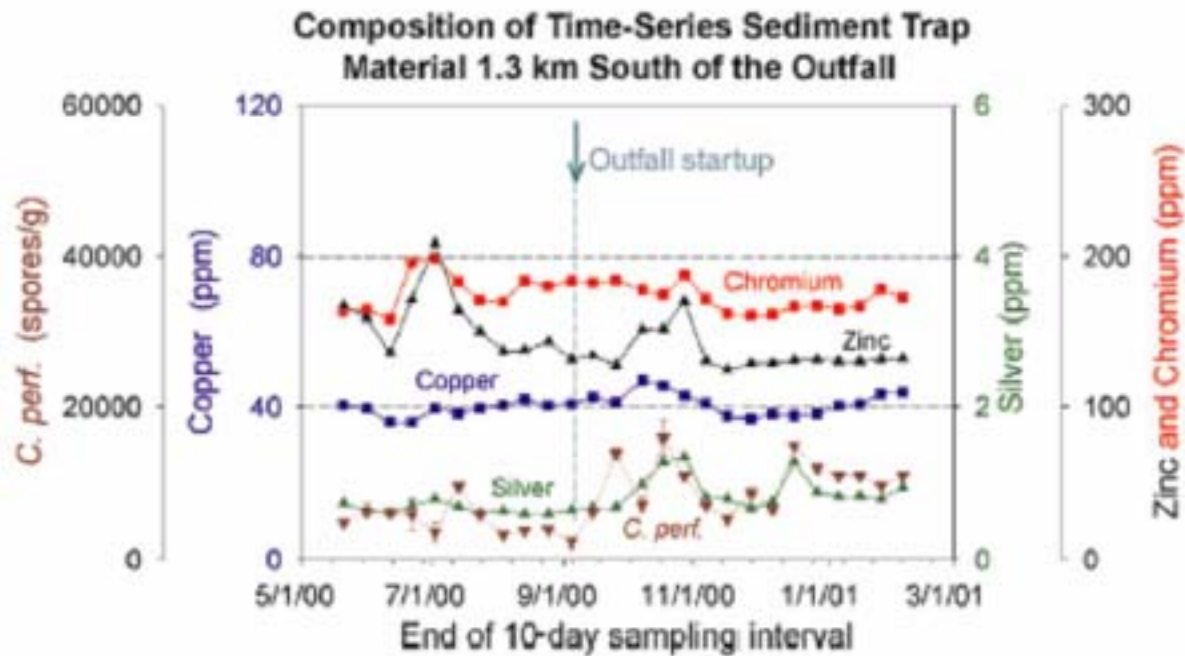
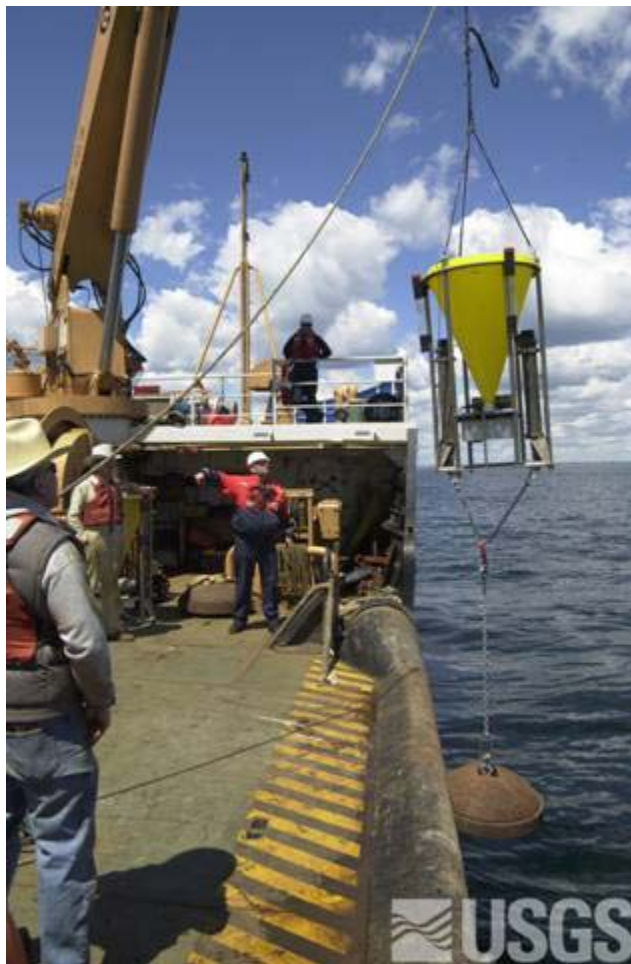
Outfall monitoring: Mussels

- **Mussels placed in cages are suspended near the diffuser**
- **Chlordane and PAHs in caged mussels exceeded baseline values**
- **Absolute values were well below FDA limits**
- **Effluent concentrations of these constituents were below or near ambient criteria**





Outfall monitoring 2001 USGS sediment trap studies



- No changes in chromium, zinc, copper
- Slight increase in silver
- Doubling of *Clostridium perfringens* spores to levels seen when outfall was in harbor before secondary treatment



Outfall monitoring 2001 Sediments



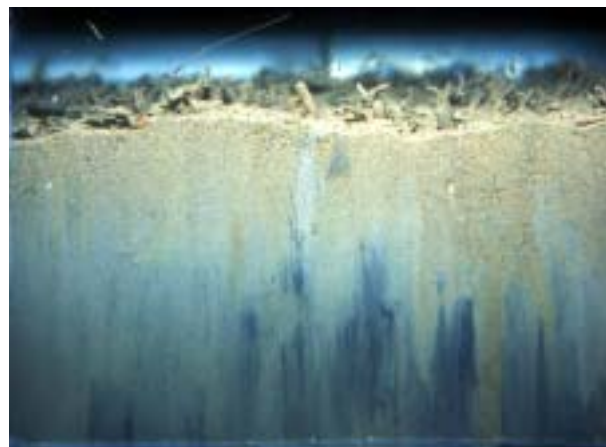
NF04-2



NF13-3



NF22-2



NF05-3

**Pictures of sediments near the outfall show healthy,
normal communities**



Outfall monitoring 2001: Summary

- **Elevated ammonium levels around the outfall as expected**
- **Chlorophyll, plankton, dissolved oxygen levels normal**
- **Caged mussel study indicates effluent effect on PAH and chlordanes, but levels are low**
- **No acute impacts on sediment contamination or bottom-dwelling communities**
- **Monitoring questions shift from acute to chronic effects**



Inactive diffuser head #2 shows healthy hard-bottom animal community